MDE Product Development Team
(Based on Work Plan for 12-month Period from 1 April 2014 through 31 March 2015)
May 2014 Monthly Report
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*(Compiled and edited by **S. Benjamin** and **B. Johnson**)*

Executive Summary

Task 1: Improve Turbulence Guidance From NWP Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

- Operational RAPv2 continues to run reliably at NCEP.
- RAPv3 and HRRR code now frozen for 2014 warm season exercise, on 5 April for RAPv3 and 10 April for HRRR.
- Development continues for further assimilation and model improvements in RAP.
- Results of test of initial pre-NARRE 8-member ensemble (4-NMMB, 4-ARW) retrospective experiment very encouraging.

Task 2: Improve Quality Of Convective Weather Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

- HRRR in April and May performing particularly well in many convection cases.
- New RAPv3 showing much less nighttime cold bias over snow than oper RAPv2.
- Warm and dry daytime bias in 2-m temperature and dew point in prefrontal southerly flow in RAPv3 is under active investigation. This bias is reduced in RAPv3 (ESRL) vs. RAPv2 (NCEP-operational) but still is a major focus in MDE work at GSD.

Task 3: Improve Quality Of Icing Weather Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

- Extensive set of the physics changes, along with data assimilation and other model improvements to both the RAP and HRRR forecast systems were implemented for the 2014 warm season evaluation as summarized in the following report: **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf.**
- Initial successful tests run made at GSD within Rapid Refresh of aerosol-aware microphysics scheme from NCAR (Greg Thompson) within WRFv3.6.
- Initial tests also made within RAP of improved lake surface temperatures through FLAKE lake model also within WRFv3.6.

Task 4: Develop Convection-ATM-Specific Improvements To Guidance From The HRRR (And Later, HRRRE) And, Interact With CoSPA (Or Other) Program Partner Labs And The FAA

- GSD froze all data assimilation and model changes for ESRL RAPv3/HRRRv2 as of 10 April 2014 on Jet and Zeus. The ESRL RAPv3/HRRRv2 changes will be implemented at NCEP in 2015.
- The real-time frozen ESRL RAPv3/HRRRv2 system will continue to run with gridded field dissemination during the CoSPA season that began on 17 April 2014 and will run until 01 November 2014.
- ESRL HRRR "failover" capability to use feed from Zeus instead of Jet during Jet downtime continues to work.
- ESRL HRRR output format changes for alignment with the NCEP HRRR operational implementation will be coordinated with COSPA program partner labs.

Task 1: Improve Turbulence Guidance From NWP Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

Improving turbulence forecast quality involves efforts to improve initial conditions for the RAP and NAM (and HRRR and NAM Nest models) and to improve the models (WRF-Advanced Research WRF (ARW)-RAP and NOAA Environmental Modeling System (NEMS)- Nonhydrostatic Multi-scale Model – B (NMMB)).
Tasks will include:

- Continuing evaluation of RAPv3 toward 2015 implementation at NCEP, incorporating changes developed in 2013 and early 2014
- Development of RAPv4 toward 2016 implementation at ESRL and subsequent implementation at NCEP. (Note, some improvements from RAPv4 will be thoroughly tested in all seasons and included in the RAPv3/HRRRv2 package for NCEP.)
- Collaborating on developing and testing best approaches for use of hybrid/EnKF/3DVAR data assimilation within common GSI coding structure.

ESRL

Regarding the operational NCEP RAP

The RAPv2 continues to run well in NCEP operations, without any model or post-processing issues during May.

The RAP web page **http://rapidrefresh.noaa.gov** **is** updated with information on the operational RAPv2 configuration including a February 2014 NWS webinar ppt on RAPv2 - **http://ruc.noaa.gov/pdf/RAPv2-NWSwebinar-18feb2014-FINAL.pdf.** A link to the RAPv2 Technical Implementation Notice is there also. A webpage on RAP output grids from NCEP is at **http://ruc.noaa.gov/rr/RAP-NCEP-output-grids.html.**

RAPv3 model testing and evaluation

During May, using the ongoing daily RAP verification, an increasing daytime warm and dry forecast bias became evident east of the Rockies under conditions of mostly clear skies and low-level southerly flow with dry soil conditions. This is not a new problem; the RAPv3 performance in this regard is, in fact, somewhat better than for the RAPv2 now running at NCEP. Nevertheless, the Storm Prediction Center, in particular, regards this as a serious issue and it is under intensive investigation by GSD (see Task 3). Related to this, when there is a southern-plains dry line, the dry line position often tends to be slightly too far east.

As reported last month, final changes were made to the warm-season RAPv3 configuration in the RAP-primary cycle at GSD on 5 April. This cycle continues to drive the HRRR-primary running at GSD in support of the 2014 warm-season exercise. We expect to keep this cycle frozen through 30 September 2014. A summary of the upgrades from RAPv2 going to RAPv3 (and HRRRv2) has been published on the web **http://ruc.noaa.gov/pdf/RAPv3-HRRR-April2014.pdf** with a more detailed description available at **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf**. This version has been running well, with a substantially reduced nighttime cold bias in the forecast, particularly over snow cover, relative to that of the operational RAPv2. (See FY2014Q2 report, Task 3 for changes made to mitigate this cold bias.) The HRRR actually is least prone to the warm/dry daytime forecast bias, less so than RAPv3 or RAPv2, although this bias is evident even in the HRRR.

NARRE-related activities

Major progress in May-June - Now that GSD has successfully run the NMMB on Zeus, including the same version of the Unified Postprocessor (UPP) as used in the RAP, Isidora Jankov (GSD-AMB) has completed testing a preliminary ensemble configuration using both ARW and NMMB cores on retrospective cases. There are 4 NMMB members and 4 ARW members running over the RAP domain. The members are initialized from the Global Ensemble Forecast System (GEFS), either from the GFS control member (one member from each core, or from particular GEFS members (the other 3 members from each core). The ARW members have different physics configurations as well. Examination of the forecast ensembles resulting from this testing is very encouraging, showing desirable properties regarding reliability (verification falls mostly within the range of solutions provided by the ensemble) and ensemble spread.

Subtasks

14.5.1.1 Ongoing **(NCEP, GSD**)
Maintain hourly RAP and HRRR runs and provide grids of SAV and AHP guidance products.

There were no issues with the RAP in May. Work continued on the HRRR implementation scheduled for September. (Manikin) The NESDIS 3-hourly GOES satellite winds were replaced by the new hourly winds. RAP ob dumps were modified and now provide a complete set of GOES IR and WV winds for each RAP cycle. (Keyser)

14.5.1.2 28 July 2014 **(NCEP, ESRL & CAPS)**
Discussions were held on the development of convection-allowing ensemble data assimilation using GSI/NMMB between J Carley and U. Oklahoma faculty during a May visit to SPC/NSSL for the Spring Forecast Experiment. Context of these discussions is a new NSF Visiting Scientist Program at NCEP – NARRE and HRRRE would leverage results if this comes to pass. (Carley, Wu, Parrish)

ESRL

GSD (Ming Hu) is preparing a new GSI repository from which MDE research partners (GSD, EMC, CAPS, OU, others) will check out common software for regional ensemble data assimilation toward NARRE.

Ming Hu has performed new experiments in April for different localization options for the hybrid/EnKF data assimilation for the RAP. He found that the current configuration, although with relative small localization scales, seems to produce equal or optimal results. As of June, these localization options may be repeated.

NCEP

Work has not begun as of May. (Carley, Wu, Parrish)

14.5.1.3 30 Sept 2014 **(CAPS, GSD, EMC)**
Test and evaluate direct radial velocity and reflectivity data assimilation within the 40-20km/13km dual resolution hybrid system. (Resolution dependent on computing resources)

CAPS

Due to significant reductions of funding to CAPS in previous years and somewhat for FY2014, development work at CAPS for direct assimilation of radar data in the EnKF and hybrid systems will be limited (most of this work was proposed under plan B for FY2014 which was not funded). Still, efforts have started at CAPS to introduce this capability into the hybrid GSI system, borrowing the reflectivity observation operator from the ARPS 3DVAR system, which considers 3 ice phases. The reflectivity operator will need to be made consistent with the Thompson microphysics used by RAP, which also predicts the total number concentration for rainwater.

EMC

Work continued to improve the assimilation of radial winds into GSI by tuning the observation weights based on various factors. Unfortunately, the changes led to improved 00Z forecasts and degraded 12Z forecasts. Work also continued to refine use of radar-derived temperature tendencies in the diabatic filter initialization (DFI), in which preliminary results showed the changes led to improved precipitation forecasts but colder upper-level biases in 3-h NDAS forecasts. (Liu, Carley)

14.5.1.4 1 Jan 2015 **(ESRL, CAPS)**
Test the 40/13 km dual-resolution system with hourly DA cycles including all observation types, including radar reflectivity data via cloud analysis and DDFI.

14.5.1.5 28 Feb 2015 **(NCEP, ESRL & NCAR)**
Groups collaborate on developing and testing physics schemes between WRF and NEMS' physics layer.

NCEP

Another series of experiments in May looked at a period in January 2014 when the daytime 2-m cold biases were pronounced. The results, summarized on **this web page,** showed that changes to several land-surface parameters had the largest positive impact in improving 2-m air and dew point temperature forecasts. Additional sensitivity tests eliminated the effects of canopy wetness, but these changes failed to reduce the daytime 2-m cold and moist biases seen in NMMB runs from last winter. The regional NMMB model code in the NEMS was updated to version 3 of the RRTM radiation, which is the version being used in the GFS. (Ferrier, Aligo, Jovic)

GSD

GSD successfully tests a preliminary NARRE configuration testing ARW with RAP and NAM-like physics and also with NMMB using NAM physics, and will next expand the NMMB options including the Thompson MP scheme.

14.5.1.6 28 Feb 2015 **(NCEP)**
Complete testing of improved or extended 88D processing and quality control, taking advantage of dual-pol where possible.

Modifications to the Level II decoder for build-15 (SAILS) were tested in real-time parallel runs and evaluated. Moving this into Production is expected. (Liu)

14.5.1.7 15 Mar 2015 **(ESRL, CAPS, NCEP)**
Complete readying of initial regional ensemble data assimilation capability to initialize real-time parallel RAP version and NAMRR.

NCEP

The NAMRR was configured to run with the Rocoto workflow manager on Zeus, and a complete suite of analysis diagnostic routines was added. A bug that severely affected the GSI runtime performance on Zeus was found and fixed, improving resource usage by up to 50%. This fix was also added to the pre-implementation NAM, but the impact on WCOSS resources was much less significant. Testing on Jet might be called for. (Carley, Wu, Parrish)

14.5.1.8 28 Mar 2015 **(NCEP and ESRL)**
Negotiate Data Mining List priorities with NCEP Central Operations and external points of contact associated with the most desirable new sources of observations.

NCEP

No new items were requested so Data Mining List remained unchanged. (Keyser, Whiting).

GSD

New agreements with energy companies for use of their proprietary tower and nacelle wind data were drafted in May by GSD and coordinated with NWS. This proprietary wind data is already on the DML.

14.5.1.9 31 March 2015 **(NCEP)**
Establish a pre-implementation version of the hourly updated NAMRR with a goal to use the common regional ensemble data assimilation.

No work was done in May. (Carley)

Deliverables

All Option A unless noted otherwise.

14.5.1.E1 10 April 2014 **(ESRL)**
Finalize RAPv3 and HRRRv2 for summer 2014 real-time exercise.

COMPLETE. A summary of the spring 2004 RAPv3 and HRRR v2 configurations has been published on the web at **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf**

14.5.1.E2 31 May 2014 **(NCEP)**
With approval of NCEP Director, NAMv3.1 upgrade package is implemented at NCEP.

NCO in started the pre-implementation parallel mid-May, with the official 30-day evaluation scheduled to begin in early June. (Rogers)

14.5.1.E3 30 July 2014 **(NCAR/MMM)**
Deliver a WRF Users' Workshop and a WRF tutorial for the user community.

NCAR continued organizing the 2014 WRF Users' Workshop, which will be held June 23–27 at NCAR's Center Green facility. Over 175 have registered thus far. The first day lecture session will address WRF best practices, while the core of the workshop will feature three days of talks on developments and applications, as well as discussions. The final day will offer mini-tutorials on NCL, VAPOR, WRF-Hydro, LAPS, and MPAS.

NCAR/MMM is planning the next WRF tutorial. This will be held July 21–August 1 at NCAR. It will include a basic WRF tutorial, a WRFDA tutorial, a WRF regional climate tutorial, and a WRF-Chem tutorial. Registration is currently open.

Presentations will be made by GSD on the RAP/HRRR configurations of the WRF-ARW model (Weygandt) and on pre-NARRE experiments (Isidora Jankov).

PLANNED EFFORTS: NCAR will host the WRF Users' Workshop June 23–27, 2014. NCAR will organize and lead the next WRF tutorial in July.

UPDATES TO SCHEDULE: NONE

14.5.1.E4 20 Oct 2014 **(ESRL)**
Code for RAPv3 and HRRRv2 finalized for transfer to NCEP/EMC for 2015 implementation.

Progress has been steady with testing having started with WRFv3.6, earlier in the year than GSD has done previously with the annual WRF release. This includes testing of aerosol-aware cloud microphysics as described in more detail under Task 3.

14.5.1.E4.1 31 Mar 2015 **(ESRL)**
Report on wind accuracy from RAP and HRRR by quarter for previous year, strongly related to turbulence guidance.

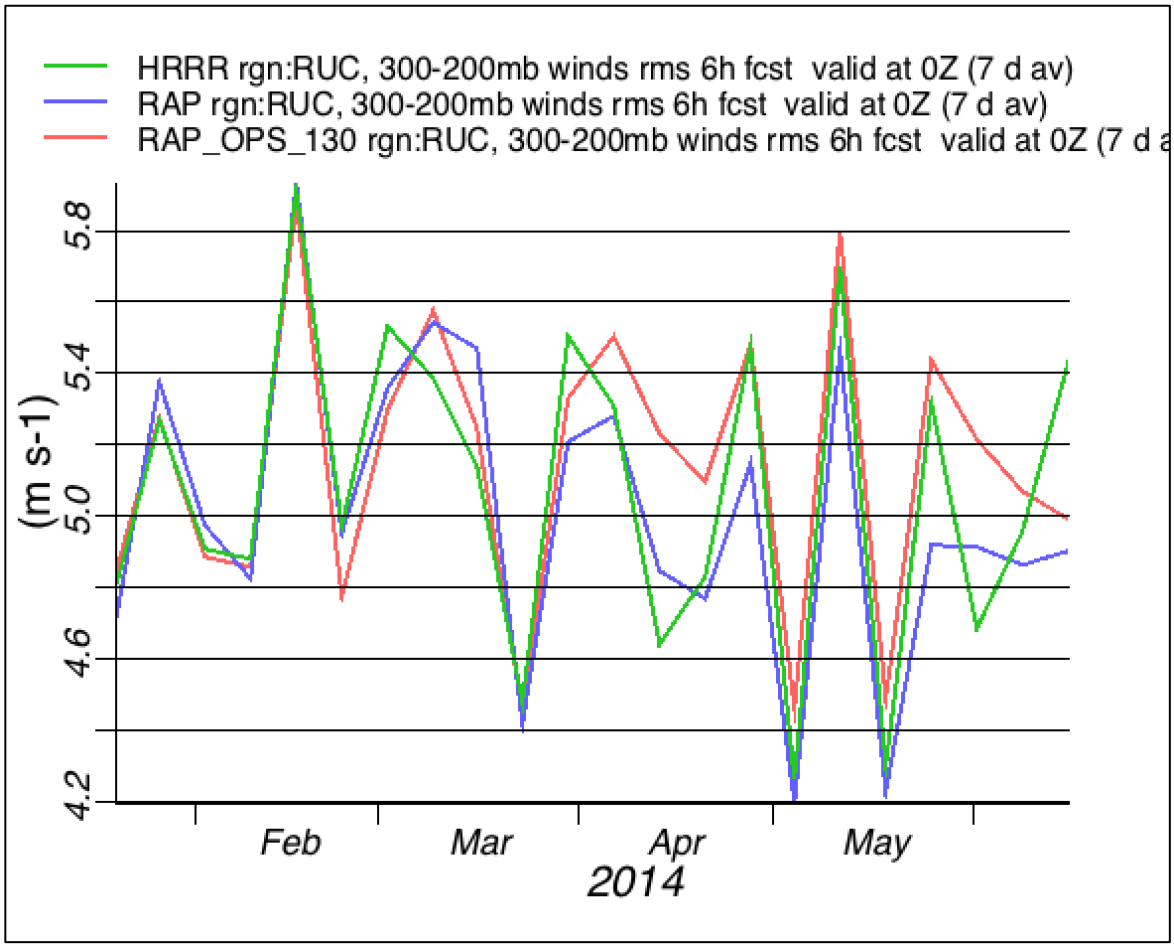

Figure 1: Upper-level (300-200 hPa) wind forecast RMS vector error vs. raobs for 6h forecasts from RAPv3 (ESRL, in blue), RAPv2 (NCEP, in red), and HRRR (ESRL, green). All scores are from native gridded data, not from isobaric coordinate data and show 7-day averages for forecasts valid at 00z. Units – m/s.

An initial look at upper-level 6h forecast wind accuracy over the last 5 ½ months shows relatively similar wind accuracy between the operational RAP (red), ESRL RAP (blue), and ESRL HRRR (green) as shown in Fig. 1. After the introduction of RAPv3 and HRRRv2 in the ESRL runs in early April, those updated runs are generally showing improved wind forecast skill over that from the NCEP RAP (red). This also means that turbulence guidance, heavily dependent on upper-level wind forecast accuracy, has also been improved from this update. Details on the RAP-HRRR updates in early April 2014 are described in **http://ruc.noaa.gov/pdf/RAPv3-HRRR-April2014.pdf** and **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf**. Verification against aircraft observations is also shown in Fig. 2 but only for the ESRL RAP (changing from RAPv2 to RAPv3 in early April). In future months, results from the NCEP RAP and HRRR models will be added to allow comparison for winds vs. aircraft observations.

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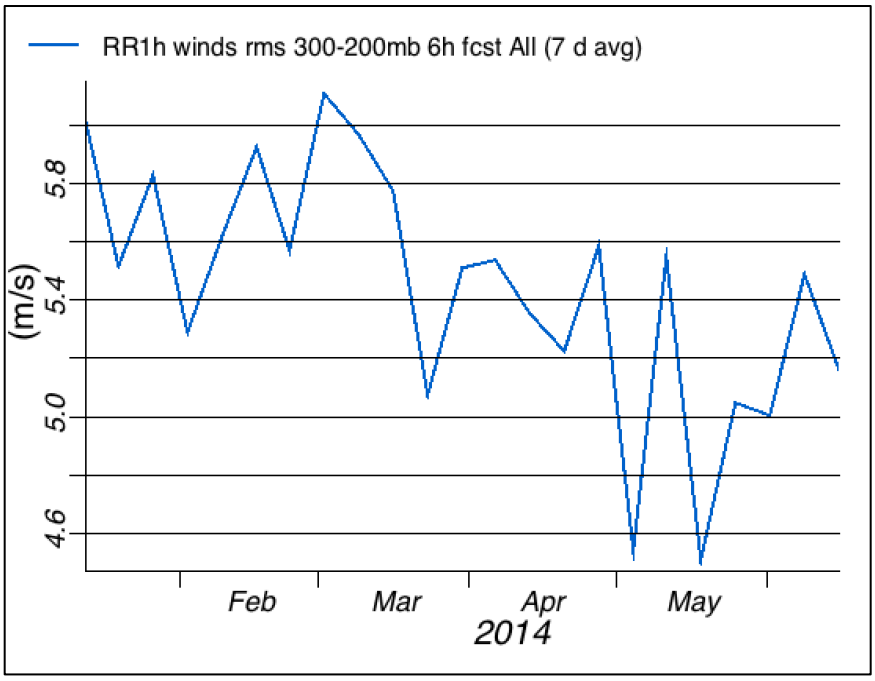

Figure 2: Upper-level (300-200 hPa) wind forecast RMS vector error vs. aircraft for 6h forecasts from RAPv3 (ESRL, in blue). Units – m/s.

14.5.1.E5 31 Oct 2014 **(ESRL, CAPS, NCEP)**
Complete the testing of the 40-20/13 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data.

CAPS

In May, Gang Zhao of CAPS set up the 40-km coupled hybrid GSI-EnKF system for RAP on Zeus, and repeated the experiments documented in Pan et al. (2014 MWR) paper for the 20100507-20100517-test period. Once the results are verified to be correct, the system will be tested for a new period chosen by GSF from summer 2013. Later, the tests will migrate towards a new merged version of GSI.

NCEP
No work was done in May. (Carley)

GSD

GSD has tested localization options for the GFS-ensemble-based covariances for the 40km hybrid DA system for RAP. GSD is also setting up a GSI repository for use for common GSD-NCEP-CAPS experimentation for hybrid ensemble data assimilation development.

14.5.1.E6 20 Dec 2014 **(ESRL)**
Report on RAPv3 model and data assimilation configuration and progress. This will include a report on wind verification and its improvements in RAPv3 vs. RAPv2.

14.5.1.E7 31 Jan 2015 **(ESRL and NCEP)**
Finalize code for RAPv3 to NCO for implementation at NCEP.

GSD

GSD is carefully evaluating RAPv3 performance as described in the general information under Task 1 above. A set of further changes anticipated as possible for fall changes to the ESRL RAP code before transfer to NCEP for the final NCEP-RAPv3 configuration has been established. This set includes WRFv3.6, aerosol-aware microphysics, and improvements to GSI data assimilation including treatment of surface observations and assimilation of cloud and radar data.

NCEP

The RAPv3 code being tested by ESRL will not be given to EMC until after the HRRR implementation. (Manikin)

14.5.1.E8 31 Jan 2015 **(ESRL, NCEP)**
Pending NCEP computer readiness and EMC and NCEP initial recommendations, Requests for Change (RFCs) are filed to submit code changes as part of upgrade for RAP v3 software to NCO.

NCEP

This work will not begin until after the HRRR implementation. (Manikin)

14.5.1.E9 31 March 2015 **(NCAR/MMM)**
Incorporate physics and dynamics improvements into WRF from the user community, GSD, and NCEP for use in the RAP and HRRR. Oversee code preparation and integration of these improvements into the WRF repository for future model version releases and FAA use. Assist in the implementation of bug fixes. In collaboration with GSD, assist in the development and evaluation of physics schemes for the RAP and HRRR that are contributed to the ARW.

GSD, and NCEP for use in the RAP and HRRR. Oversee code preparation and integration of these improvements into the WRF repository for future model version releases and FAA use. Assist in the implementation of bug fixes. In collaboration with GSD, assist in the development and evaluation of physics schemes for the RAP and HRRR that are contributed to the ARW.

NCAR released WRF Version 3.6 on April 18, 2014. This major release contains WRFDA 3.6, as well as updates to WPS, HWRF, and WRF-Chem. This represents months of preparation and oversight, summarized in previous reports. Details of WRF V3.6 may be found at: **http://wrf-model.org/users/release.php**.

Jimy Dudhia (NCAR/MMM) and Ming Chen (NCAR/MMM) investigated and corrected an issue with the Penn State shallow convection scheme that is under development. The problem appeared in differences in results from serial and parallel runs, and they passed the fix back to Penn State. This scheme is being prepared for a future WRF release.

Dudhia and Pedro Jimenez (CIEMAT, Spain) have been testing a new oceanic surface roughness formulation, evaluating it via verification of WRF forecast winds with ocean wind energy site observations. The formulation appears more suitable for shallow seas, and development is ongoing.

Dudhia consulted with Jim Bresch (NCAR/MMM) in work toward robust changes for the use of WRF diffusion option diff_opt=2 (diffusion along horizontal surfaces) in complex terrain. They are seeking formulations that reduce diffusion in steep terrain gradients in complex terrain. While the WRF V3.6 version of diff_opt=2 had a fix that included a slope-dependent factor (designed by Joe Olson of GSD and now being used in the HRRR, NCAR sees need for further options and they are now testing a deformation-dependent component.

PLANNED EFFORTS: The development and incorporation of new physics and dynamics for WRF for the RAP and HRRR will continue through this quarter.

UPDATES TO SCHEDULE: NONE

14.5.1.E10 31 March 2015 **(ESRL and NCEP)**
Deliver progress report on development of NARRE.

NCEP

Seventeen products were added (per WPC request) to the high-resolution NCEP Convection-Allowing Ensemble (NCASE) in preparation for WPC's Flash Flood and Intense Rainfall (FFaIR) experiment. These new products (related to thunderstorms and heavy rain) will be available on the **NCASE website** for WPC evaluation by early June. (Du, Zhou, Yang, Jovic)

Deliverables **Task 1: Improve Turbulence Guidance From NWP Forecasts**	**Delivery Schedule**
A. Finalize RAPv3 and HRRRv2 for summer 2014 real-time exercise.	APR 2014 **COMPLETE**
B. Code for RAPv3 and HRRRv2 finalized for transfer to NCEP/EMC for 2015 implementation. **Strong progress toward this at GSD through RAPv3/HRRRv2 current real-time evaluation.**	OCT 2014
C. Complete the testing of the 40-20313 km dual-resolution hybrid DA system for RAP with 3-hourly cycles with conventional data.	OCT 2014
D. Report on RAPv3 model and data assimilation configuration and progress. This will include a report on wind verification and its improvements in RAPv3 vs. RAPv2. **Preliminary RAPv3 configuration already available in http://ruc.noaa.gov/pdf/RAPv3-HRRR-April2014.pdf.**	DEC 2014
E. Finalize code for RAPv3 to NCO for implementation at NCEP.	JAN 2015
F. Report on wind accuracy from RAP and HRRR by quarter for previous year strongly related to turbulence guidance. **Initial evaluation on wind accuracy from RAP and HRRR vs. raobs and aircraft observations has been started and included in this monthly report.**	MAR 2015
G. Requests for Change (RFCs) filed to submit code changes as part of upgrade for RAPv3 software to NCO.	MAR 2015
H. Deliver progress report on development of NARRE.	MAR 2015

Task 2: Improve Quality Of Convective Weather Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

Subtasks

14.5.2.1 15 April 2014 **(GSD)**
Report on enhancements to RAP 13-km and HRRR 3-km radar data assimilation for beginning 2014 warm-season evaluation using the ESRL-updated version of the HRRR (i.e., HRRRv2).

COMPLETE: As reported in the April 2014 MDE report:
Following extensive testing and evaluation, a RAP/HRRR change bundle was made in late March 2014. The package includes changes to both the data assimilation and model portions of both the RAP and HRRR forecast systems and is summarized in the following report: **http://ruc.noaa.gov/pdf/ESRLRAPHRRRchanges2014.pdf**

The testing involved single-case study experiments, retrospective evaluations, and real-time parallel cycles of individual changes and grouping of changes to check all aspects of the change bundle. The change bundle was a mix of addressing known issues and adding new capabilities. Highlights of the change bundle for the RAP include enhancements to the hybrid data assimilation and the cloud analysis, improvements in the snow cycling and dew point assimilation, and upgrades to the Grell-Freitas (GF) cumulus parameterization and the MYNN planetary bounder layer scheme. Highlights for the HRRR include most of the RAP enhancements plus adding a hybrid assimilation procedure and adjustments to the strength of the reflectivity-based diabatic heating. Also, both the WRF model and GSI analysis were updated to the latest community repository versions.

Statistical evaluation of both the RAP and HRRR retrospective and real-time parallel runs showed broad improvement in nearly all aspects (upper-air, surface, precipitation, reflectivity, etc.). Recent real-time performance has been quite good, with impressive skill demonstrated for recent convective cases as shown in Fig. 1.

14.5.2. 15 May 2014 **(GSD)**
Improved (optimized weight factors, and observation selection) 15-min HRRR-based RTMA.

Request for delay to 1 Sept 2014.
A key scientist to work on this task left GSD for another position in March. There has been some experimentation done on improved observation selection for the HRRR-based RTMA but more work will be done before the new requested due date.

14.5.2. 5 August 2014 **(GSD)**
Complete testing of updated version of 3-km sub-hourly radar assimilation within HRRR pre-forecast cycling period.

Testing continues in May 2014. Initial testing reported in April report with figure. Changes made for 2014 warm season evaluation, resulting in reduction of high bias during first few HRRR forecast hours.

14.5.2. 20 Oct 2014 **(GSD)**
Complete 2014 HRRR summer evaluation using modeling and assimilation modifications determined in 2013 exercise. Collaborate on analysis of HRRR tests and deliver summary of results.

14.5.2. 15 Dec 2014 **(GSD)**
Based on 2014 RAP and HRRR results, provide update report on development and testing of data assimilation and model enhancements important for improving forecasts of convective weather within the RAP and HRRR.

14.5.2. 1 5 Dec 2014 **(GSD)**
Single-case test of storm-scale ensemble data assimilation completed for HRRR over small Northeastern U.S. domain.

14.5.2. 15 March 2015 **(NCEP)**
Establish routine verification of NCEP suite of convective weather guidance and begin design of calibration strategy for ensemble systems.

NCEP

Work continued on new codes/scripts that contain special severe-weather parameters for operations. Scripts for the grid2grid verification upgrade were tested. (Zhou, Du, Yang, Shafran)

Deliverables

14.5.2.E1 1 August 2014 **(NCEP and ESRL)**
HRRRv1 implemented at NCEP pending available computing resources.

NCEP and ESRL

More pieces of the HRRR were handed off to NCO in May to help build their test system, which will eventually become the official parallel. As of the end of May, the system is running nearly end-to-end on WCOSS each hour in test mode. (Manikin)

14.5.2.E2 1 April 2014 **(NCEP)**
Subject to NCEP Directors' approval, upgrades to HiResWindow and initial convection-allowing-scale ensemble (NSSE) becomes Operational at NCEP.

NCEP

Performance issues highlighted by forecasters during the parallel test period were investigated. AWC noted echo top height degradation in the parallel WRF-ARW, which appears to be largely driven by the change to WSM6 microphysics. WPC pointed out that the relative skill of the parallel for precipitation forecasts was more variable than expected ("varied wildly"); EMC had also noticed this behavior. Some initial work points to the change from NAM to RAP initial conditions over the CONUS as playing a role (model changes aside, for some days a RAP analysis will generate a better precipitation forecast, while on others a NAM analysis will be better for this purpose). Both will be used in the HRRRE era. (Pyle)

14.5.2.E3 1 April 2014 **(NCEP)**
With approval of NCEP Director, RTMAv6 upgrade package is implemented at NCEP.

NCEP

The RTMA/URMA upgrade version 2.2.1 was implemented on January 28, 2014, Manuel Pondeca, Steve Levine, Yanqiu Zhu, Ying Lin, Jeff McQueen, Geoff Manikin, Jim Purser, Dave Parrish, Yuqiu Zhu)

14.5.2.E4 15 July 2014 **(ESRL)**
Report on status of enhancements to HRRR for 2014 version, based on retrospective and real-time testing. .

14.5.2.E5 15 Oct 2014 **(ESRL)**
Complete 2014-summer evaluation with revised 3-km HRRR running every 1 h.

- Conduct real-time summer 2014 HRRR forecasts using 3-km WRF with 3-km assimilation initialized with radar-enhanced Rapid Refresh over full CONUS domain, monitor performance, modify code/scripts as needed, maintain high reliability working with ESRL computer facility
- Coordinate with other AWRP users and other collaborators, including coordination of HRRR grid transfers
- Provide project management
- Lead writing of report on summer 2014 HRRR experiments

14.5.2.E5.1 31 Mar 2015 **(ESRL)**
Report on convective weather forecast accuracy from HRRR by quarter for previous year.

14.5.2.E6 15 Nov 2014 **(ESRL and NCEP)**
Based on real-time parallel and retrospective testing, HRRRv2 code finalized and ready for transfer to NCEP/EMC

Note: Already, this date may need to be deferred since the HRRRv1 implementation is now planned for Sept 2014.

NCEP

HRRRv1 must be implemented at NCEP before any transfer to EMC of the HRRRv2 code currently being tested at ESRL can be considered. (Manikin)

ESRL

GSD continued to evaluate HRRRv2 during the real-time 2014 warm-season exercise.

14.5.2.E7 15 Jan 2015 **(ESRL, assistance from CAPS under 5.1 support)**
Report on initial retrospective test of storm-scale ensemble data assimilation for small Northeast U.S. domain.

14.5.2.E8 31 Jan 2015 **(ESRL/GSD, NCEP)**
Pending NCEP computer readiness and EMC and NCEP initial recommendations, Requests for Change (RFCs) are filed to submit HRRR code changes as part of upgrade for HRRR v2 software to NCO.

NCEP

This work has not yet started. (Manikin)

ESRL

Real-time evaluation showing good skill overall of HRRRv2 shows promising results toward its 2015 NCEP implementation.

14.5.2.E9 1 Feb 2015 **(ESRL and NCEP)**
Provide revised 15-min RTMA surface analyses as improved alternative for frontal diagnostics and other diagnostics from surface analyses for CoSPA.

ESRL

GSD is now running the RTMA with the new (as of April) HRRRv2 as a background field. Initial results appear very reasonable. GSD will work again with National Weather Service for

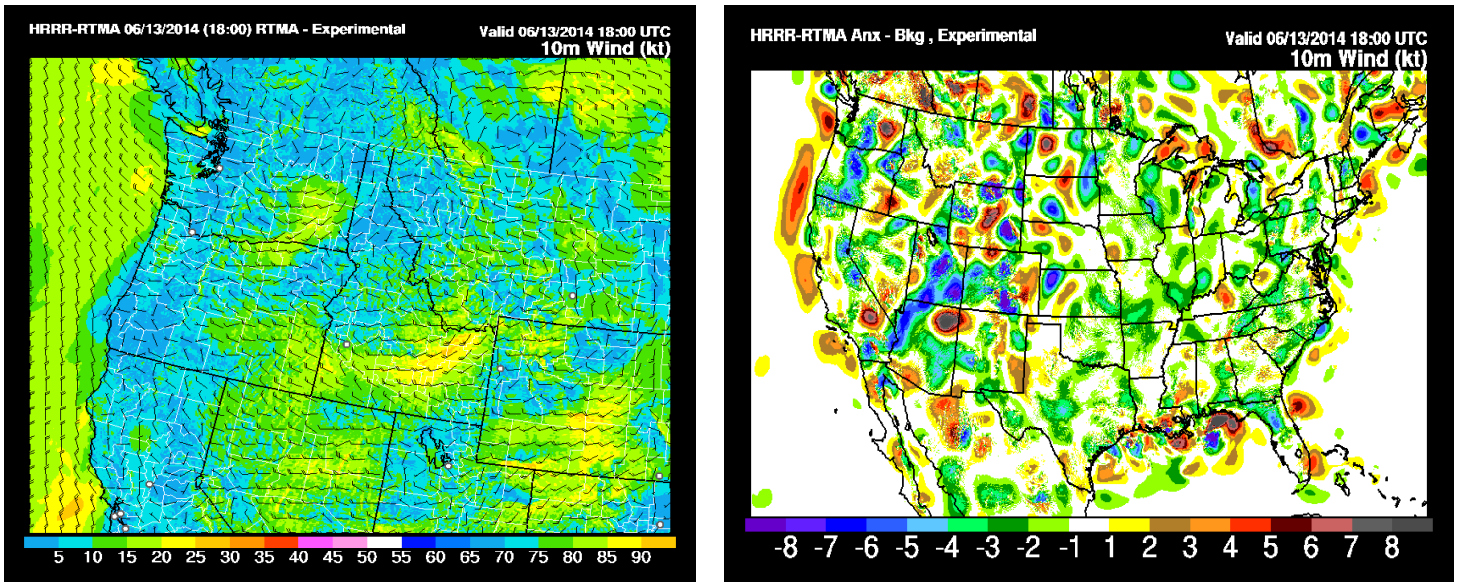

Figure 2: 10m wind speed and direction from RTMA with HRRR background for 18z 13 June 2014. a) Full field, (above) b) analysis increment using observations and HRRR background.

NCEP

Work continues to add the analysis of ceiling and cloud amount (sky cover) [as well as 10-m wind speed (scalar), 2-m dew point, daily maximum and minimum temperature, mean sea level pressure, and significant wave height] to the GSI. Preliminary tests have been satisfactory. New observation processing is needed for ceiling and max/min temperature. Extensive testing will be performed when the code enhancements have been merged with the official GSI, which has just undergone a major update. Testing of a new variational observation quality control (QC) procedure has been initiated with the expectation that it will help with some of QC issues that have been found, especially over the complex terrain of western region. (Manuel Pondeca, Steve Levine, Jim Purser)

14.5.2.E10 15 March 2015 **(ESRL)**
Finalize all changes to the HRRR for the summer 2015 exercise into a frozen version of HRRR (and parent experimental RAP). This will include latest results on reflectivity verification.

Deliverables **<u>Task 2: Improve Quality Of Convective Weather Forecasts</u>**	**Delivery Schedule**
A. HRRRv1 implemented at NCEP pending available computing resources **STATUS: Now planned for Sept 2014 as of May 2014.**	AUG 2014
B. Report status of enhancements to HRRR for 2014 version, based on retrospective and real-time testing.	JUL 2014
C. Complete 2014-summer evaluation with revised 3-km HRRR running every 1 h. Conduct real-time summer 2014 HRRR forecasts using 3-km WRF with 3-km assimilation initialized with radar-enhanced Rapid Refresh over full CONUS domain, monitor performance, modify code/scripts as needed, maintain high reliability working with ESRL computer facility Coordinate with other AWRP users and other collaborators, including coordination of HRRR grid transfers Provide project management Lead writing of report on summer 2014 HRRR experiments	OCT 2014
D. Based on real-time parallel and retrospective testing, HRRRv2 code finalized and ready for transfer to NCEP/EMC.	NOV 2014
E. Report on initial retrospective test of storm-scale ensemble data assimilation for small Northeast U.S. domain.	JAN 2015
F. Requests for Changes (RFCs) are filed to submit HRRR code changes as part of upgrade for HRRRv2 software to NCO.	JAN 2015
G. Provide revised 15-min RTMA surface analyses as improved alternative for frontal diagnostics and other diagnostics from surface analyses for CoSPA.	FEB 2015
H. Report on convective weather forecast accuracy from HRRR by quarter for previous year.	MAR 2015

I. Finalize all changes to the HRRR for the summer 2015 exercise into a frozen version of HRRR (and parent experimental RAP). This will include latest results on reflectivity verification.	MAR 2015

Task 3: Improve Quality Of Icing Weather Forecasts From RAP, HRRR, NAM, NAM-Nests And, Eventually, NARRE And HRRRE

Subtasks

14.5.3.1 1 Apr 2014 **(GSD NCEP and NCAR/RAL)**

Begin initial testing of the current version of NCAR "aerosol-aware" microphysics in RAP and HRRR models. This will use a climatological aerosol distribution for cloud-condensation nuclei and ice nuclei initially.

The WRFv3.6 release version including the NCAR-developed aerosol-aware microphysics is now running at GSD twice daily, cold starting from the GFS initial conditions. We are comparing this to a parallel cold-start running with the RAPv3 configuration (WRFv3.5.1 Thompson microphysics). Figs. 4 and 5 show en example of comparison between 12-h accumulated precipitation and total cloud cover from a pair of cold-start runs. Because there are other differences between these two runs other than microphysics it is not possible to argue that all the differences seen below are due to the aerosol-aware microphysics. Note that there are somewhat larger areas covered by precipitation with the aerosol aware microphysics, in some cases larger precipitation amounts, also more area of scattered or broken cloud cover with the aerosol microphysics, more area of solid or clear with the aerosol unaware. More extensive controlled testing will be necessary to establish to what extent these differences are characteristic.

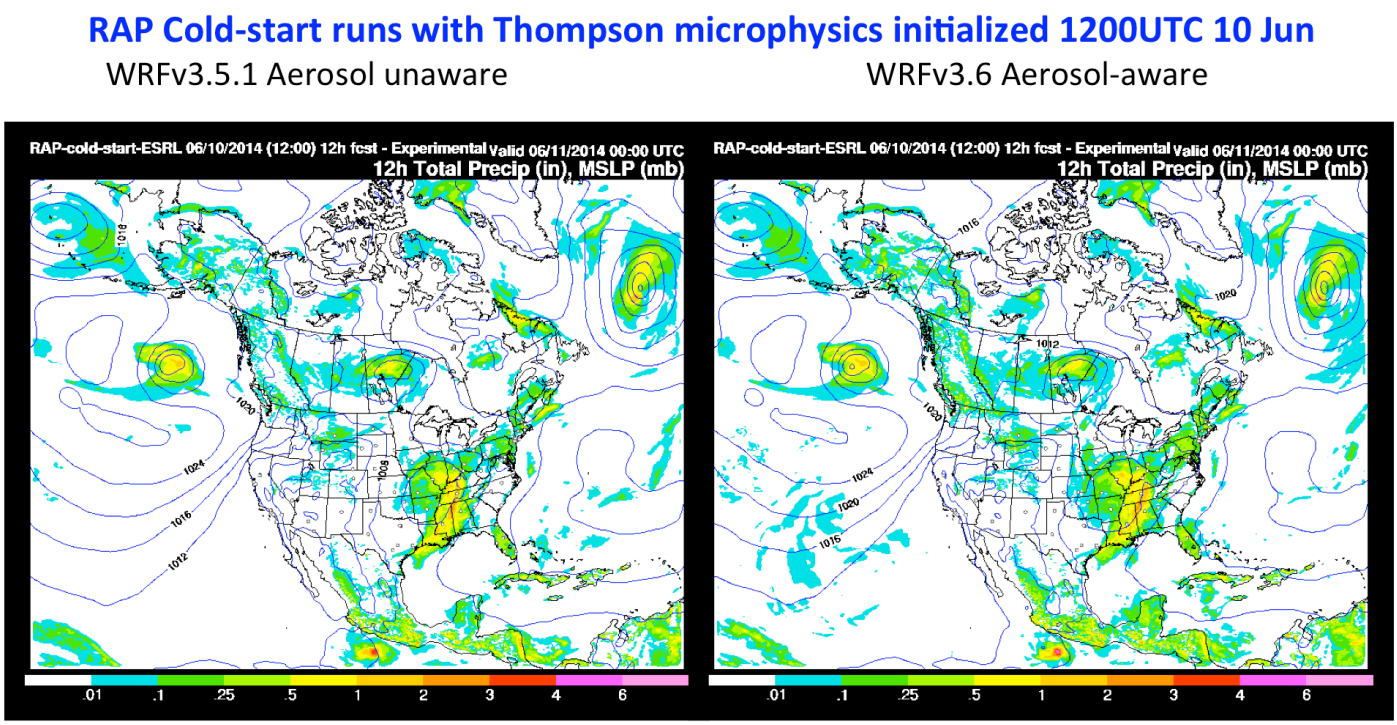

Figure 4: Accumulated 12h precipitation in inches from cold start runs initialized 1200 UTC 10 June 2014. Image on the right is using the aerosol-aware microphysics.

RAP Cold-start runs with Thompson microphysics initialized 1200UTC 10 Jun

WRFv3.5.1 aerosol unaware WRFv3.6 Aerosol-aware

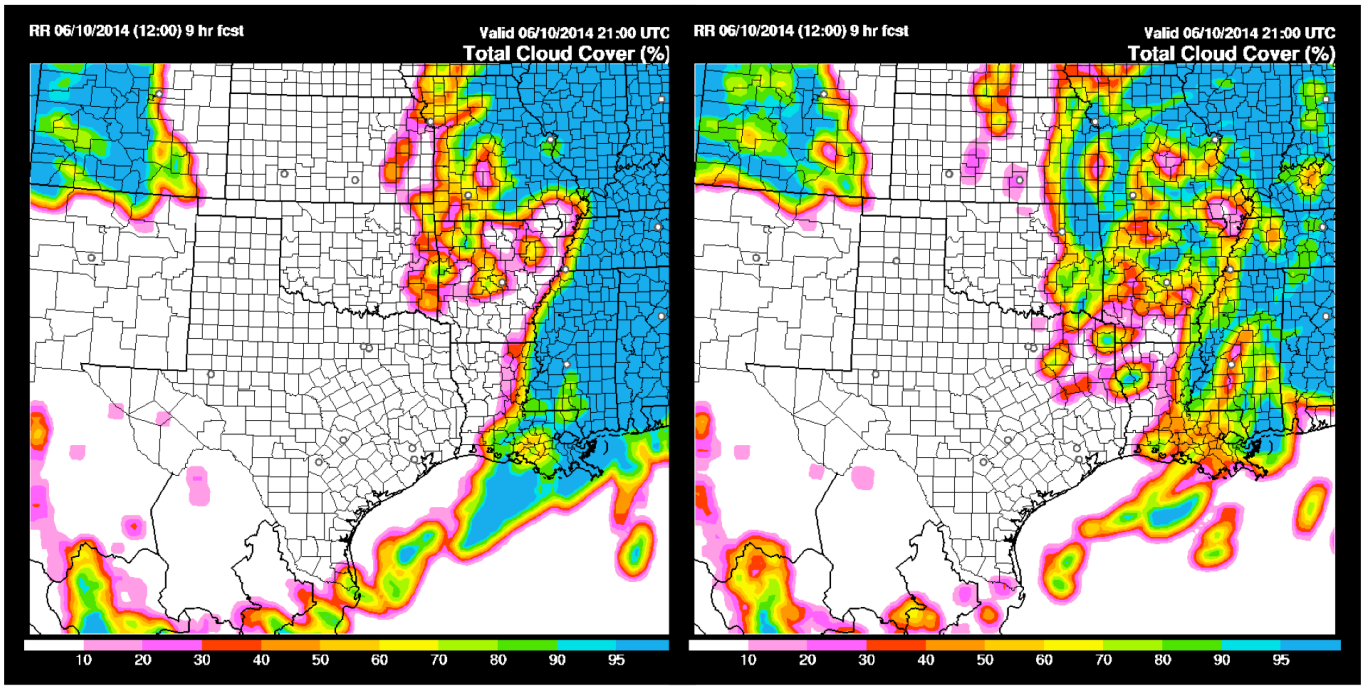

Figure 5: As Fig. 1 for total cloud cover (per cent) from cold-start 9-h forecasts from 1200 UTC 10 Jun 2014 valid 2100 UTC 10 June 2014.

GSD is also now testing another new physics parameterization, using the FLAKE lake model allowing improved estimate of lake surface temperatures. GSD is also using this lake model within its real-time RAP WRFv3.6 cold-start runs. The FLAKE lake model will likely be a component to RAPv4 and possibly to the proposal NCEP-RAPv3 this fall. Its use will likely improve near-surface conditions in the RAP and HRRR models in areas near small-size lakes (i.e., smaller than the size of the Great Lakes) for which we do not have good lake surface temperatures currently. We will report more on this in subsequent months.

NCEP

No work was done in May using “aerosol-aware” microphysics in any of the NMMB systems. (Ferrier, Aligo)

14.5.3.2 1 Apr 2014 **(GSD)**
Continue evaluation and modification of proposed RAPv3 physics suite in preparation for submission of code to NCEP, pending NCEP readiness, later in 2014.

The modifications (see Task 3 in FY2014Q2 report) made for RAPv3 to ameliorate the nighttime cold bias over snow cover are working well. Although the bias is not eliminated, it is substantially reduced over that in RAPv2.

As noted under Task 1, east of the Rockies we have been seeing, in both RAP and HRRR a systematic, daytime warm temperature bias and low dewpoint bias in regions of southerly flow in the warm sector of surface cyclones. The problem seems to be exacerbated when soil moisture is very dry. (Although this bias is reduced in RAPv3 vs. RAPv2, it is still large and requires improvement.) An ancillary issue is that when there is a dry line over the southern Plains, it is often forecast a little too far east. We have noted this type of behavior in previous years with the MYNN scheme and retro runs suggest that our current use of the RRTMG with its accounting for attenuation of solar radiation by climatological aerosol is helpful. However, our recent experience with the RAP-primary running our current RAPv3 physics configuration indicates that the change to RRTMG alone is clearly not sufficient.

We are pursuing two approaches to this issue. Joe Olson working with Georg Grell continues to pursue this issue using the RAP-dev2 real-time cycle for evaluation of the shallow component of the Grell-Freitas convection scheme and it’s coupling with radiation. Joe and Jaymes Kenyon are also testing reformulations of the MYNN surface-layer scheme that has promise of reducing the surface heat flux during the middle of the day without making it too large during the subsequent evening transition. Further, alterations to the MYNN boundary layer scheme that better account for counter

gradient heat flux near the top of the mixed layer are also being tested. Evaluation of these changes using real-time and retrospective testing is underway. GSD will also investigate the possibility of inadvertent asymmetry in soil moisture adjustment within GSI.

Record pre-monsoonal heat in the Sonoran Desert of northwest Mexico led to a crash in the RUC land-surface scheme during the HRRR pre-forecast step in early June. This was tied to large skin-temperature changes due to imbalances in the surface energy budget at the first time step of the pre-forecast cycle, exacerbated by the downscaling from RAP to HRRR (the RAP experienced no problems). A fix to extend the range of possible skin temperatures in the RUC LSM prevented further crashes. A limit to skin temperature change per model time step will likely be later added to the RUC LSM, similar to the limit to latent heating from cloud microphysics installed into WRF to similarly improve model stability.

14.5.3.3 1 May 2014 **(GSD and NCAR/RAL)**
Begin efforts toward adding aerosol species or size categories as tracers to the RAPv3 and HRRR configurations of the WRF model, including surface sources, which are highly parameterized in the first version of the new microphysics scheme. Interact with WRF-Chem experts for aerosol source datasets, surface emission inventories, and translation of specific aerosol variables into the constituents needed by the microphysics scheme.

Discussions have started between GSD and NCAR about how to incorporate prognostic aerosol information from the RAP-Chem run into experimental versions of the RAP and HRRR.

14.5.3.4 1 May 2014 **(NCEP)**
Perform case-study simulations of high-impact weather events in order to evaluate NMMB model running the existing and newly added Thompson et al (2008) microphysics schemes.

NCEP

Work began to get the Thompson microphysics to run with version 2 of the RRTM radiation (used by upcoming NAM) without breaking the coupling with other microphysics, and progress has been good. A follow-on effort to get the Thompson microphysics to work with version 3 of the RRTM radiation (used by GFS) is expected to be complete before the end of June, in preparation for the DTC's tests of the Thompson scheme. (Ferrier, Aligo, Lin)

14.5.3.5 1 Jun 2014 **(NCAR/RAL)**
Test and evaluate the ice initiation mechanisms via aerosols to ensure the water-ice balance is relatively un-changed versus the prior scheme or else the updated scheme may result in significant loss of skill of aircraft icing forecasts since water is rapidly depleted by ice when too many ice crystals are supplied.

14.5.3.6 1 Sep 2014 **(NCAR/RAL)**
Continue to increase the complexity and interactions between the newly added aerosol variables in the microphysics with the PBL, radiation, convection, and shallow convection schemes. Particular focus will be the depletion of aerosols nucleated by sub-grid-scale eddies, the effects of which are represented by the PBL and convection schemes.

Current efforts: Initial test simulations were run at NOAA-GSD to test the new aerosol-aware Thompson & Eidhammer (2014) microphysics scheme with climatological aerosols. Together with funding leveraged from DOE-Solar-WRF project, NCAR-RAL & MMM + NOAA-GSD are forming a plan for more coordinated usage of the RAP-Chem aerosol variables into the inputs of the microphysics scheme, which needs fewer variables. Also, lookup tables were created to compute aerosol optical depth from the reduced set of aerosol variables for ultimate use by the radiation scheme.

Future work: NCAR-RAL will assist NOAA-GSD to adopt/utilize the new scheme. Trude Eidhammer will resume additional testing of the ice initiation by aerosols in the next month or two.

Problems encountered/Delays: Subtask#6 contains many unknowns due to numerous dependencies with other physics routines. Work may not begin on this subtask until after 1 Oct 2014.

Interface with other organizations: Various DOE Solar-WRF team members including GSD

Deliverables
(All Option A unless noted otherwise)

14.5.3.E1 1 Aug 2014 **(NCAR)**
Submit updated cloud microphysics code to WRF repository; document changes and purpose of changes in a report.

14.5.3.E2 31 Aug 2014 **(ESRL)**
Complete initial evaluation of aerosol-aware microphysics in RAP/HRRR test evaluation/demonstration at GSD for its suitability for future NCEP implementation.

14.5.3.E3 1 Dec 2014 **(NCAR)**
Submit a report and possible journal manuscript related to the aerosol-ice sensitivity experiments including specific application to aircraft icing.

14.5.3.E4 20 Dec 2014 **(ESRL)**
At the annual NCEP Product Suite Review report on RAP / HRRR physics upgrades. This will include metrics on improvement to cloud and RH forecasts from these physics upgrades.

14.5.3.E4.1 31 Mar 2015 **(ESRL)**
Report on RH/cloud forecast accuracy from RAPv3 and HRRRv2 by quarter for previous year, related to icing guidance.

14.5.3.E5 31 Jan 2015 **(ESRL/GSD, NCEP)**
Pending NCEP computer readiness and EMC and NCEP initial recommendations, Requests for Change (RFCs) are filed to submit WRF physics code changes as part of upgrade for Rapid Refresh v3 software to NCO.

NCEP

This work has not yet started. (Manikin)

Deliverables **Improve Quality Of Icing Weather Forecasts**	**Delivery Schedule**
A. Complete initial evaluation of aerosol-aware microphysics in RAP/HRRR test evaluation/demonstration at GSD for its suitability for future NCEP implementation. **ESRL/GSD: The aerosol-aware microphysics are now running in an experimental real-time RAP run ("Cold-Start-Run-2")**	AUG 2014
B. At the annual NCEP Product Suite Review report on RAP/HRRR physics upgrades. This will include metrics on improvement to cloud and RH forecasts from these physics upgrades.	DEC 2014
C. Requests for Change (RFCs) are files to submit WRF physics code changes as part of upgrade for Rapid Refreshv3 software to NCO.	JAN 2015
D. Report on RH/cloud forecast accuracy from RAPv3 and HRRRv2 by quarter for previous year, related to icing guidance.	MAR 2015

Task 4: Develop Convection-ATM-Specific Improvements To Guidance From The HRRR (And Later, HRRRE) And Interact With CoSPA (Or Other) Program Partner Labs And The FAA

Subtasks

14.5.4.1 15 Aug 2014 **(GSD)**
Initial testing toward variational / ensemble cloud analysis scheme within the GSI framework.

A preliminary planning meeting was held with ESRL/GSD and NCAR to present and discuss approaches for a variational/ensemble cloud analysis. This discussion included a work plan to create a common GSI source code repository and add cloud water and cloud ice control variables and static background errors in GSI. Longer-term plans include creation of cloud water and ice observations based on cloud coverage and testing of cloud water/ice retrievals in a variational framework that can be compared to the original non-variational cloud analysis.

14.5.4.2 15 Nov 2014 **(GSD, NCEP)**
Finalize new cloud/hydrometeor analysis for 2015 RAPv3/HRRRv2

NCEP

No work done in May. (Liu)

14.5.4.3 15 Feb. 2015 **(GSD, NCEP)**
Report on progress toward variational/ensemble cloud analysis

NCEP

No work done in May. (Liu, Wu, Carley)

14.5.4.4 15 March 2015 **(NCEP, ESRL)**
Groups collaborate on initial work toward cloud analysis scheme for use in NARRE ensemble system.

NCEP

No work done in May. (Liu, Wu, Carley)

14.5.4.5 31 March 2015 **(ESRL, NCEP)**
Establish routine verification of NCEP suite of ceiling & visibility guidance and begin design of calibration strategy for ensemble systems.

NCEP

Grid2grid verification of echo top is being resurrected because of AWC's interest and negative feedback concerning new ARW running in HiResWindow. Grid2grid ensemble verification of FIM forecasts was configured to run on Zeus in support of the High Impact Weather Prediction Project (HIWPP). Scripts were tested on WCOSS for the grid2grid verification upgrade for aviation weather (visibility). (Zhou, Shafran, Du, Yang)

Deliverables

14.5.4.E1 1 April 2014 **(NCEP)**
With approval of NCEP Director, RTMAv6 upgrade package is implemented at NCEP (including visibility).

The RTMA/URMA upgrade version 2.2.1 was implemented on January 28, 2014, (Manuel Pondeca, Steve Levine, Yanqiu Zhu, Ying Lin, Jeff McQueen, Geoff Manikin, Jim Purser, Dave Parrish, Yuqiu Zhu)

14.5.4.E2 1 June 2014 **(NCEP)**
With approval of NCEP Director, SREF, HiResWindow and NAM upgrade packages are implemented at NCEP (including corrections to ceiling, visibility and cloud field prediction & diagnoses).

Presentations on EMC's mesoscale modeling for aviation and on the RTMA/URMA and challenges of verification were given 14 and 15 May at the NWS' MWO/RAM meetings in Silver Spring MD. (DiMego) The work of next SREF upgrade has just been started, which includes dropping WRF-NMM members, increasing vertical resolution from 36 to 41 levels, distributing 3 base analyses (GFS, NAM & RAP) across two dynamics, and redesign of physics diversity. The verification system was set up to calculate Fractional Skill Scores (FSS) for all NCEP mesoscale models, including the parallel HiResWindow domain to cover all of CONUS. Forecasts of surface fields from the NCEP models were verified against the Unrestricted Mesoscale Analysis (URMA). (Du, Zhou, Yang, Jovic, Pyle, Rogers)

14.5.4.E3 15 Dec 2014 **(ESRL/GSD)**
Finalize cloud/hydrometeor assimilation for RAPv3 and transfer code to NCEP.

14.5.4.E4 15 Feb 2015 **(ESRL/GSD)**
Report on variational / ensemble/hybrid cloud analysis development for RAP and NARRE

14.5.4.E5 31 March 2015 **(NCEP)**
Subject to NCEP Directors' approval, upgrades to RTMA/URMA (addition of total cloud and cloud base height [ceiling]) become Operational at NCEP.

A presentation on the EMC activities and the RTMA system was given at the 2014 Alaska Grid and Science Meeting in Anchorage. As a result, Eugene Petrescu from Alaska HQ visited EMC to share advanced wind downscaling code. The code was added to the SMARTINIT downscaling repository. Support continues for the real time diagnostic RTMA and RTMA parallel experiment webpages, and work began to add cloud-ceiling heights to the RTMA analysis. (Pondeca, Carley, Levine)

Deliverables **Task 4: Develop Convection-ATM-Specific Improvements**	**Delivery Schedule**
A. Report on ATM impact related to skill of HRRR forecast.	FEB 2015
B. Complete implementation of new microphysics scheme and associated reflectivity and ET diagnostics in real-time ESRL/GSD RAP and HRRR prior to code freeze for 2015-exercise release.	MAR 2015
C. Report on baseline testing of the early 2015 HRRR version.	MAR 2015
D. Report on evaluation of revised Thompson aerosol-aware microphysics for RAP/HRRR for its effects on echo-top and reflectivity in ESRL RAP/HRRR.	MAR 2015